THE INTERACTION BETWEEN PROPAGATING DISTURBANCES AND SUPERCRITICAL MARINE LAYERS ON THE WEST COAST OF THE UNITED STATES

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LONG-TERM GOALS

In the future, we hope to expand our investigations into the dynamics of the marine layer. Particularly important are trapped events in the marine layer and the dynamical implications of supercriticality of the marine boundary layer.

We have a interest in long, internal gravity waves in the marine layer. The basic climatology and the spectrum based upon a time period greater that a year is needed. How are these waves generated? Do gravity waves have a significant effect on the surface wind stress, and if so, under what conditions?

As satellite techniques improve, we would like to adapt remote sensing techniques to determining boundary layer conditions over the eastern sides of oceans. We wish to investigate the relationship between the large scale, upper atmospheric forcing and the marine boundary layer response.

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OBJECTIVES

With this project, we see the following objectives:

a. Develop a description of the summer marine boundary layer along the west coast.

b. Test the hypothesis that the west coast marine layer between Cape Mendocino and Pt Conception is supercritical during a significant portion of the summer.

c. Investigate coastally trapped events. What is the feed back between a progressive trapped event and the marine boundary layer? What are the differences between type of trapped events? What is the role of capes in halting northward progression by trapped events? Are there trapped events that are held quasi-stationary by either southbound flow or topography? What are the offshore scales associated with trapped events? Are trapped events south of Cape Mendocino different than those to the north? What is the interaction and response of the air field immediately above a trapped event in the marine layer? Do leading edges of trapped events radiate gravity waves?

d. Investigate internal gravity waves in the atmospheric marine layer. The spectrum and basic statistics of internal gravity will be developed for the summer season.

e. To determine the mean and turbulent structure of the coastal marine boundary layer.

f. To determine the alongshore and across-shore variability of the marine layer.

g. To determine coherent fields in marine layer and their effect on the maintenance and organization of coastal clouds

The functional objectives are:

a. Construct 13 automated meteorological stations.

b. Deploy the automated stations on 15 May and retrieve on 15 October 1994.

c. Deploy the automated stations on 1 May and retrieve on 15 October 1996 (added since beginning of the project and to be covered in a supplemental request).

d. Do quality control and reformat time series from the surface automated stations. Variables are wind components, pressure, air temperature and humidity.

e. Retrieve time series of meteorological data from agencies that would otherwise have been lost (Monterey County Water Authority, Bodega Bay Marine Lab, P.G.&E).

f. Make RAF C-130 research aircraft flights along Central California in the summer 1994.

APPROACH

a. Make summer surface and aircraft measurements along the California and Oregon coast.

b. Combine other sounding and profiler measurements from other sources to make a data net that extends from San Diego, California to Newport, Oregon.

c. Apply theories to and test hypothesis on the data network.

WORK COMPLETED

a. Thirteen Automated stations constructed

Stations were constructed rather than purchased to have properties that were not easily incorporated in purchased stations at a better price. Improvements include minute

averages, the highest accuracy commercially available pressure sensor in a remote station, aspirated temperature and humidity seasons and memory logged on flash cards.

b. Stations deployed and maintained along the California coast and from 10 May through 15 October 1994.
c. Data from the 1994 season has been converted to calibrated values, reformatted, quality controlled and transferred to the mainframe system.
d. Twelve RAF C-130 flights were made along the central California Coast in July 1994.
e. Automated stations were refurbished and prepared for the 1996 field season.
f. Automated stations deployed and maintained along the West Coast between Piedras Blancas, CA to Gold Beach, OR from 12 May through 20 October 1996.
g. Data from the 1996 season has been converted to calibrated values, reformatted, quality controlled and transferred to the mainframe system.
h. Draft of manuscript prepared for Pt Sur supercritical flow case.

RESULTS

a. A major trapped event occurred in the marine layer on 9/10 June. This was monitored by satellite, where a stratus cloud formed in the Southern California Bight, moved up the central coast. It continued up to bump into Pt Arena. Wind reversals at the NDBC buoys began near Santa Barbara, are strongest near Point Conception, and extend but weaken up to Pt Arena. The leading edge of this stratus event was very thin when we observed it on the ground approaching Pt Sur. Examination of the NWS upper air charts suggests to us that this event was a trapped event and not a directly forced response by a synoptic scale feature.

b. Offshore measurements of the coastal boundary layer were obtained during June 1994 using the UK Meteorological Office C-130 Hercules aircraft. The primary mission of this platform was to support the Monterey Area Ship Tracks (MAST) experiment. Dual purpose flights enabled us to obtain plume and cloud information in the vicinity of ships and also detailed measurements of the horizontal and vertical structure of the marine layer. Large gradients in sea surface temperature, variations in coastal topography, fetch, and the land-sea boundary all contribute to the heterogeneity of the coastal boundary layer. Rapid sampling of the boundary layer using aircraft allowed us to resolve spatially coherent fields. Combined with the long time series data from fixed measurement sites along the cost we will be able to obtain a comprehensive picture of the evolution of the marine boundary layer. There have been several numerical studies of the development of coherent rolls in the marine layer, particularly downstream of continents in large sea-air temperature gradients. These convective rolls are often buoyancy driven as very cold air flows over relatively warm water. In the cases under investigation we observe well-defined rolls that are primarily shear-driven with distinct coherent spectral peaks in the velocity field. It is estimated that about 20% of the total wind stress and 10% of the turbulent kinetic energy and sensible heat flux is contributed by the rolls. Besides contributing to the fluxes the rolls determine fields of convergence and divergence that organize the stratus clouds in lines and may contribute to the longevity of ship tracks embedded in coastal stratus.

c. Measurements during the 1996 summer season show that when sea level wind speeds are fast, they are fast from Cape Mendocion to Pt Conception. During these times, the atmospheric marine layer Froude number is greater than one or supercritical for all of the major capes including Cape Mendocino, Pt Sur and Pt Conception. Extensive expansion fans radiate downwind and offshore of the Capes. A horizontal, coastal boundary in the marine layer is of the order 50 km wide at Cape Mendocino expands to 150-200 km wide along central California.

IMPACT/APPLICATIONS

The system of 13 automated meteorological stations may be used again for another season to make high quality, high frequency measurements of the coastal zone.

TRANSITIONS

Data from this project was exchanged with NRL Monterey. This included surface observations and aircraft data that was used to test and evaluate the NRL COAMPS model. A copy of all surface hourly observations for the 1994 season has been transferred to Dr. Wendell Nuss in the Meteorology Department at the Naval Post Graduate School so that he may relate the synoptic scale with the local coastal response.

RELATED PROJECTS

1. Within ONR

We have combined our data and work with Wendell Nuss (profiler and sounding data in the Monterey Bay area), and Bill Neff (Profilers at several sites). This forms an antenna to capture the structural aspects and investigate the dynamics of the marine layer. John Baine's light aircraft flight data is being used to shed light on the 9/10 June 1994 trapped event and conditions in the Santa Barbara Channel in 1996.

2. Mast

Sounding data study in the Monterey area that was taken during the MAST June 1994 intensive will be utilized. We are maintaining contact with MAST investigators to make available our data bank.

3. MM Santa Barbara/Santa Maria Basin Study

We are pooling data with this project to extend the data net coverage along the coast. The MM study has 5 automated meteorological station in the Santa Barbara Channel which was useful for investigating the source of the 9/10 June 1994 trapped event and will be helpful in looking other events that occurred in the 1996 summer season.

4. NSF Coastal Waves Project

The National Science Foundation funded Rogers and Dorman to make NCAR C-130 flights along the California coast in June 1996. Tracks were flown at multi levels down to 30 m and as far as 120 km offshore off the major topographic caps as Cape Mendocino, Pt Sur and Pt Conception. These observations provide an extension of measurements of the marine layer properties both offshore and between stations alongshore.